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A Novel Approach for Remote Control of Lightings using PIC32 Microcontroller

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Abstract— **In the modern world, Lightings are essential for our house. Lightings irradiate our desired colors. They also have an impact on our daily behavior and mental health. The lighting fixtures are located far from our location at a particular instant. In such scenario, a remote control for lightings becomes a necessity. This paper describes an interesting approach to control a lighting using the PIC32 microcontroller. It involves detection of button, design of LED circuit and the radio frequency communication circuit. The remote control will have four buttons to switch on, off and to brighten and dim the lighting. The microcontroller acts as an interface where all the analog and digital manipulations takes place. It detects the button press and generates the PWM signal which controls intensity of the lighting. Radio communication circuit involves two radios which communicate with each other on the 2.5 GHz range using data, addressing and pipelining approaches. Such an embedded product will not only ease life of human beings but also save a significant amount of energy.**

Index Terms—**PWM, PIC32, nrf24L01+, button, LED.**

1) INTRODUCTION

Remote control is crucial in this fast paced world. With the introduction of remote control, controlling embedded devices has been simplified. Development in the field of embedded control systems has played an important part in introduction of remote control. Imagine that you sit on a sofa tired after travelling whole day and then you want to watch TV or switch on a light or a fan. Here a remote control can easily help you switch the electronic equipment from a certain distance. Another need for remote control is energy saving. With the world undergoing a radical change, the number of electronic equipment is increasing exponentially and hence it is necessary for us to efficiently utilize the energy. The approach described in this paper also provides benefits of reduced consumption of energy owing to the use of buttons for controlling the intensity of the lightings.

Choice of Wireless media

There are many approaches available for wireless remote controlling of an equipment. Wireless transmission in the infrared spectrum is very useful in case of remote control in televisions. The infrared (IF) spectrum has a wavelength between 700 nm to 1 mm. The main advantage of an infrared wireless control is its high directionality. However infrared waves are impenetrable through obstacles and walls. There may be some obstacle between the lighting and the remote control because of which infrared waves is not a good choice for remote control of lightings. Radio frequency (RF) waves have several advantages over infrared waves. These waves are penetrable through walls. Moreover it has a better range than Infrared waves, can propagate in all directions and at lower frequencies can also bend through obstacles.

Choice of lighting

Choice of the lighting is also essential when considering the energy requirements. Incandescent lamp can be a classic choice as it is compatible with the dimmer switch. However the energy requirement of an incandescent lamp is extremely high. Moreover production of all the standard incandescent bulbs has stopped and hence they are out of market so it doesn't really make sense to use it. Compact Fluorescent Bulbs (CFL) is a better option over the incandescent lamps due to its reliability and low energy consumption. However it is not compatible with the dimmer circuitry and hence does not make a good choice. Light Emitting Diodes (LED) bulbs are energy efficient, reliable and have been the most common type of lighting in modern houses. LED is basically a p-n junction diode which gets illuminated when electric current passes through the compound semiconductor material that makes the p-n junction diode. LED bulbs are available in variety of wattages. The only problem with the LED is that produces significant heat while working due to which a heat sink is required to absorb the heat and prevent damage to the circuitry. In the approach described in this paper, a 5 W bulb is used which is bright enough so that different levels of light can be seen.

The rest of the paper is structured as follows: Section 2) will give a rough outline of our design. Section 3) will describe our system Section 4) shows our circuit and section 5) and section 6) will deal with results and conclusion respectively

2) OVERVIEW OF THE DESIGN

The block diagram shown in the Fig.1 has the following two main sections: the transmitter section and the receiver section. The transmitter circuit consists of a button block which consists of four buttons that will act as an original input source triggered by the users. The input will be detected by the microcontroller at the transmitter and this microcontroller will send a message to the receiver via radio circuit at the transmitter. The receiver radio circuit will receive the message and will send the same message to the microcontroller present at the receiver. The microcontroller will then send a control signal to the receive

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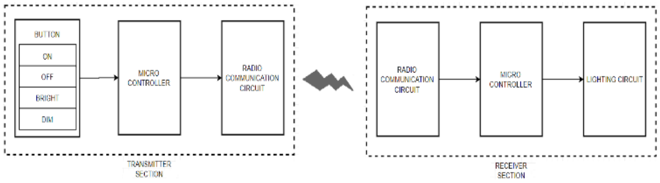

Fig.1: Block diagram representing the system

3) SYSTEM DESCRIPTION

Button Detection using PIC32

In PIC32, the A0 and A3 pins are used as the digital output and the B7 and B13 pins are used as the digital input. When two buttons are pushed simultaneously there are chances of short circuit. Hence, a 300 ohms resistor is used to avoid short circuit. There is also a chance of an open circuit when none of the buttons are pressed. To avoid this,a 10K ohms resistor is used. A snippet illustrating code for detection of buttons is shown in the Fig. 2.

```
while(1)
{
    // read each row sequentially
    mPORTAClearBits(BIT_0 | BIT_3);
    pattern = 1;
    mPORTASetBits(pattern);

    for (i=0; i<4; i++) {
        keypad  = mPORTBReadBits(BIT_7 | BIT_13);
        if(keypad!=0) {keypad |= pattern ; break;}
        mPORTAClearBits(pattern);
        pattern <<= 1;
        mPORTASetBits(pattern);
    }
```

Fig. 2: Snippet illustrating button detection using PIC32

Initially, an array named keytable is created which stores all cases of button press. The constant pattern will be scanning every row to detect if an input is present to each column. If any input has been detected to be present, the keypad is concatenated with the pattern. This should be present in keytable.

NRF radio module

The radio module which has been used for the system is nrf24L01+. This radio module is a 2.4 GHz transceiver which consists of 8 pins .The figure below illustrates the pinout of nrf24L01+ radio module. [1] Gives in depth details of this chip.

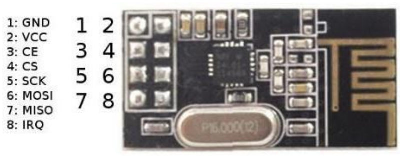

Fig. 3: nrf24L01+ pinout

Hardware connection

The nrf24L01+ radio will require an SPI connection, an interrupt pin and connections for power. The table below specifies list of pins and their connection.

Radio chip Pin number	Pin name	PIC connection pin
1	GND	GND
2	V_{CC}	V_{CC}
3	CE	Pin 17 (RB8 I/O)
4	CSN	Pin 18 (RB9 I/O)
5	SCK	Pin 20(SPI SCK 2)
6	MOSI	Pin 9(RPA2 SPI2 Data In)
7	MISO	Pin 12(RPA4 SPI2 Data Out)
8	IRQ	Pin 21(RPB10 External Interrupt 1)

Table 1: Hardware connections

Pin 1 and 2 of the radio are connected to GND and V_{CC} of PIC32 microcontroller respectively. Pin3 is the chip enable pin andpin4 is the chip select pin. These pins are control pins that are connected to the PIC32 I/O pins. As the radio communication with PIC32 takes placed through the SPI, the system usesSPI2 and SCK2 of PIC32. Pin8 of radio is the interrupt request port and is connected to external interrupt1 of PIC32. The detailed functions of the pins is listed in [2].

Software setup

In this system, the nrf_setup function of the radio will initialize SPI communication, setup the radio interrupt and the I/O pins, and reset all register values. It is very important to call nrf_setup function before calling other radio functions.

Frequency

The nrf24l01+ radio can work with 126 channels with frequency ranging from 2.4 GHz to 2.525 GHz.The frequency is set using nrf library function nrf_set_rf_ch.The equation used to calculate the frequency is given below

$$f = 2400 + ch\ [MHZ] \qquad (1)$$

Where ch denotes the frequency input to the nrf_set_rf_ch function. It is necessary that the transmitter and receiver should be equal. The code below will show how to set the the frequency to 2.5 GHz which is used for communication in our system.

nrf_set_rf_ch(0x64); // freq = 2400 + 6*16+4 MHz = 2.5GHz

Addressing and Pipelining

Addressing has been used at the transmitter and at the receiver by the nrf24l01+ radio module to determine where each packet will go. For good communication, it is required that the address on the transmitter and the receiver should be same. On the receiver, pipelining approach has been used with six pipes numbered 0-5 to fetch the data. The pipes are distinguished from each other by means of a 3-5 byte address field. This address will determine which packet will be received on which pipe. The address length is set using the nrf_set_address_width function of the nrf library. It is possible to have a unique address for every pipe to allow each of them to receive data from a different module. Pipe address is set using the nrf_set_rx_addr function of nrf library. There is an address known as TX address which will set the address with which the transmission by the radio will take place.The transmitter should have the same address as that of the pipe at which it is supposed to be received. Transmitter address can be set using nrf_set_tx_addr function.

Transmitting and Receiving the Data

The nrf24l01+ can send a packet containing up to 32 data bytes. When sending a packet, the desired number of bytes should be specified using the nrf_send_payload function. This function automatically handles the transmission. When this function is called, the radio won't be in the receiving mode anymore and therefore it is essential to set the radio back to the receiving mode for receiving packets which is done using nrf_state_rx_mode function of the nrf library. Once the radio has been set to the receiving mode it will wait to so that the packets are received. If a packet is received, a 1 is returned by the radio nrf_payload_available function and if no packet is available a 0 is returned by the function. Whenever a payload is available, a value is returned by the nrf_get_pipe function specifying the pipe at which the data has been receive. The nrf_get_payload_width function will specify the width of the payload .The nrf_get_payload function is used to read payload into a buffer. Before reading the payload it is essential to check the nrf_payload_available function to prevent the data been rejected. The received payload should be read before next payload is received to prevent it from getting discarded when the next payload arrives

4) CONTROL OF LIGHTING

Pulse Width Modulation

Pulse width modulation is a simple method to control the brightness of LED. In pulse width modulation the duty cycle of the waveform is varied due to which pulse width is change. The figure below illustrates this scheme.

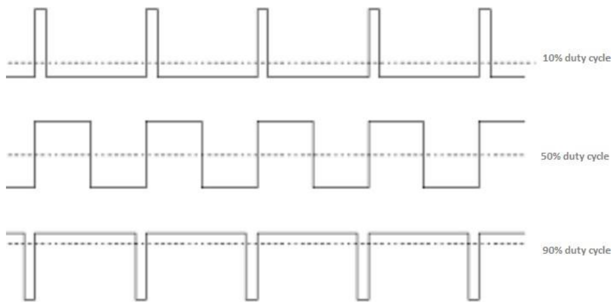

Fig. 4: Pulse Width Modulation

Duty cycle indicates the percentage of total time for which the signal is on. Hence, more the duty cycle, the more will be the average voltage. Hence by varying the duty cycle, it is possible to change the voltage to the led circuit and the brightness of led. To properly distinguish the light intensity, there are five levels of output voltage between 0V and 3.3V

Design of the lighting circuit

The lighting used for the system is 5w, 700mA LED (white color). Due to limited current supply to PIC32, the lighting cannot be directly to the microcontroller system without any safety. As a result, a separate system is designed which consists of LED circuit and transistor in order to isolate the working current of LED and PIC32. A power resistor is used to keep the current of led circuit below 700mA so that the circuit operates safely As the power supply is about 9V and led operates at 5V, the power resistor receive 4V for its operation along with a current of 700mA.Hence, we can use a power transistor of about 6 ohms.

5) CIRCUIT DIAGRAM

The transmitter and the receiver sections are shown in Fig. 5 and Fig, 6 respectively.

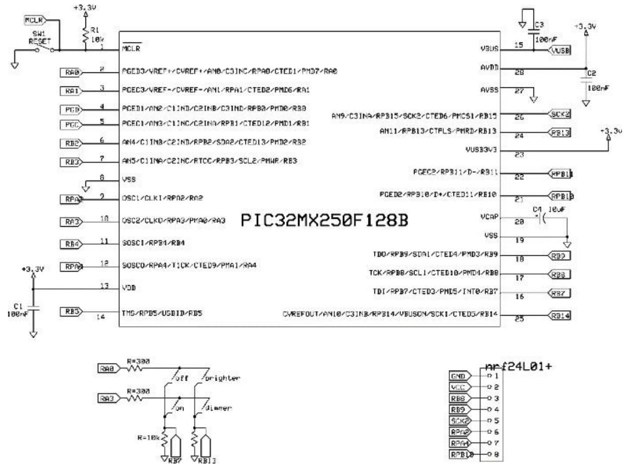

Fig. 5 Transmitter section

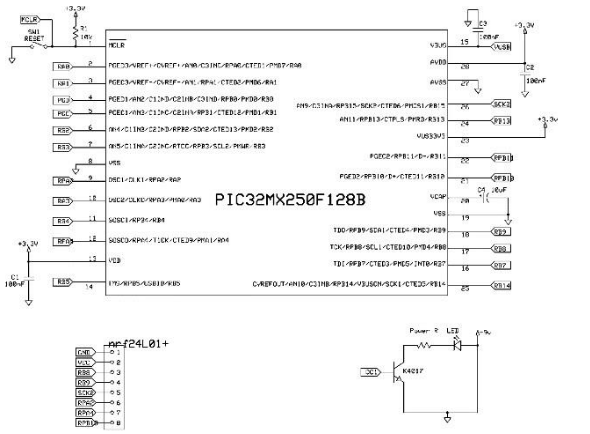

Fig. 6 Receiver section

6) RESULT

The system has its PWM set to 5 light intensities. Pressing the dim button will make the light level darker until the darkest level is reached while pressing the bright button will make the light brighter until the brightest level has been reached. Pressing on the button will turn on the light and pressing off the button will turn off the light

This system was also tested with different pipes and channels and it worked satisfactorily. A notable result was observed when the frequency of operation was changed to 2.4 GHz. At 2.4 GHz, there were more garbage messages as compared to operation at 2.5 GHz and but the system worked in the same manner as it worked at 2.5 GHz. The reason for this is at 2.4GHz frequency there is an overlap of our operation with WIFI or other wireless communication devices such as keyboard and mouse. The system was also tested for range to see the maximum distance at which the system can work properly. In our lab, we placed the receiver at one end and the transmitter at the other end. The range of our system was found to be 15 meter. Moreover, it was also found that impact of obstacles on the system was minimal.

7) CONCLUSION

The system can function well in a home environment within a range of 15 meters It is possible to make the system more convenient by adding voice control instead of pressing buttons each time. Easy voice commands such as on, off, up and down can be used.

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